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ABSTRACT

This report is comprised of a section of three talks in the special session on Mathematics and Education Reform at the January, 2000 Joint Mathematics Meeting in Washington, DC. This issue, which includes three articles based on the presentations and two additional articles, continues discussion on issues and successful approaches to improve the participation of underrepresented minorities in mathematics, especially at the graduate level and in college and university mathematics departments. Articles include: (1) "The Invisible Minorities in Mathematics" (William Yslas Velez); (2) "Graduate Education: Reconsidering Our Response" (Sylvia T. Bozeman and Rhonda J. Hughes); (3) "Increasing the Number of Minority Ph.D.s in Mathematics" (David Manderscheid); and (4) "Attracting Undergraduate Minorities to Mathematics" (Etta Z. Falconer). (KHR)

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Mathematicians and Education Reform ...Forum...

Summer 2000 *Special Issue* Volume 12 Number 3

Minority Mathematicians: Who is responsible?

by Raymond Johnson, University of Maryland, College Park

The underrepresentation of minorities in science, mathematics and engineering is frequently explained by pointing fingers. Graduate school professors complain about the quality of American students attracted to further study in mathematics. The fact that university professors trained the very students of whom they complain is rarely mentioned. It is particularly striking to me that we find the undergraduate preparation of foreign students noteworthy, but not enough to modify our training and expectations.

The same professors complain about the mathematical knowledge of students coming into the university. However, it is also unusual for mathematics professors to take responsibility for the mathematical training of elementary, middle-school and high school teachers of mathematics. The problem is always placed somewhere else— the school of education and the stifling bureaucracy in the school system are pointed to as causes— but rarely is a mirror used. The forthcoming CBMS report on the Mathematics Education of Teachers will offer departments an opportunity to contemplate their proper role in this area.

Bill Vélez has seen the effects of these attitudes on the number of minority students who receive Ph.D.'s from a variety of perspectives: as a program officer at NSF, a faculty member at Arizona and as a member and Past President of the Society for Advancement of Chicanos and Native Americans in Science. Sadly, for all of the so called good will in the mathematics community, it seems

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Minority Mathematicians: Who is responsible? was a section of three talks in the special session on Mathematics and Education Reform at the 2000 January Joint Mathematics Meeting in Washington, DC. This special issue, which includes three articles based on the presentations and two additional articles, continues the discussion about the issues and successful approaches to improve the participation of underrepresented minorities in mathematics, especially at the graduate level and in college and university mathematics departments.

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that more Ph.D.'s were produced in the "racist" forties and fifties. At least, enough good people were produced to staff the mathematics faculty at historically black colleges and minority institutions. Now, because of the poor production of minority Ph.D.'s, and because of the better job opportunities that those Ph.D.'s have, we are unable to replace retiring faculty at the historically black colleges and minority institutions.

There are, of course, many schools that are experimenting with various aspects of their curricula and I believe that over time, we will see stronger mathematics students come out of such programs, but the attitudes of the mathematics community toward its students gives them an additional hurdle to overcome.

Spelman College offers an example of a program that has always taken the education of African American women seriously. This has happened under the leadership of Etta Falconer, who served as Chair of the Mathematics Department, as Associate Dean for Science Programs and Policy, and two years as Provost of the College. She was succeeded in the first two roles by Sylvia Bozeman. While serving in these roles, Dr. Falconer initiated programs with support from NASA and NSF that served to both reform the undergraduate curriculum and to produce students for whom research is part of their identity, thus easing the transition to graduate level work. I learned how to value students from my colleagues at Spelman who regard their work as an investment in their students' future. No one wants to see an investment go bad; Spelman professors make every effort to assure that their students reach their full potential, the appropriate return on Spelman's investment.

There are outstanding examples of successful programs involving minorities in science and mathematics, but one wonders why there are not more. What is striking to me is that many of the programs, from Lee Lorch's efforts at Fisk which resulted in six undergraduate students going on to receive a Ph. D. (this had not happened at Fisk before, nor since) through Clarence Stephens efforts at Potsdam (which produced astounding percentages of math majors) up to the efforts at Spelman and Morehouse, are based on the same idea: treat students with respect, get to know them personally, build a community of scholars, and help them to realize the high expectations which they have set for themselves. All of these ideas help in building a community; while a school may occasionally succeed in getting one brilliant student through graduate school, a school has a much better chance of success working with a group.

Schools should also understand the importance to minority students of being able to return something to their community; this frequently leads to an interest in questions that have some type of real-world application. If a school has no such programs, that should be clearly explained to minority recruits. David Manderscheid describes a program, which contains many of these ideas and has been successful at the University of Iowa. If Iowa can do this, why can't other schools? The simple answer is that Departments have not made it a priority. When it is a priority, many examples of how to proceed are available to guide a University in dramatically increasing the number of minorities with degrees in science and mathematics.

"treat students with respect, get to know them personally, build a community of scholars , and help them to realize the high expectations which they have set for themselves."

Even modest increases would be welcomed. Walter Massey, when head of NSF, challenged mathematics departments to increase the number of minority Ph.D.'s they produced by one per year. It would be interesting to see how many universities have met that challenge. ■

The Invisible Minorities in Mathematics

by William Yslas Vélez, The University of Arizona

This article is written from the perspective of a Chicano mathematician. Over the years, I, like many of my Chicano colleagues, have devoted considerable energies to increasing the number of students from our cultural groups who go into mathematics-based fields. The Hispanic population in this country is growing, yet this is not evidenced in our graduate schools and among our faculty. I believe that mathematics departments have ignored the minority community in the past, and I want to point out some instances of this. I also want to make some recommendations that would serve to increase minority participation.

1. The impact of just one Chicano mathematician

Manuel Berriozabal received his Ph.D. in mathematics from The University of California, Los Angeles in 1961. He spent fourteen years at Tulane University and the University of New Orleans and finally arrived at The University of Texas, San Antonio (UTSA) in 1976, where he has continued his professional life to the present. Berriozabal is perhaps best known for the creation of the TexPREP program, which he began in 1979. This program is a mathematics-based academic enrichment program targeting middle and high school students. Its focus is on the development of abstract reasoning and problem solving skills.

Berriozabal had to overcome many obstacles along the way. When San Antonio Prep first started, the conventional wisdom was that the program was doomed to failure because middle school and high school students would never want to spend eight weeks during the summer on a college campus studying mathematics and its applications. Indeed, a San Antonio magazine published a feature article on UTSA in 1979 in which an anonymous member of the Texas Higher Education Board expressed his opposition to approving an engineering program at UTSA. In his words, "The Mexican-American community is not where engineers come from anyway."

Berriozabal's program has now been replicated in over 14 cities. More than 17,000 middle and high school students have completed at least one eight-week summer of TexPREP. 81% have been minorities and 54% have been women. A 1999 follow-up survey of former TexPREP participants revealed a high school graduation rate of 99.9%, a college entrance rate of 92% and a college graduation rate of college entrants of 90%, with 53% being awarded degrees in science and engineering.

Berriozabal, like many minority mathematicians, has a profound concern for the education of the minority children in his city. More importantly, many minority mathematicians have attempted, in some fashion, to act on this concern. If every mathematics department had such individuals, we would now see a different make-up of the professorate. It takes years to develop talent. With so few minority mathematicians in our universities, this under-representation will continue to exist. Had mathematics departments, which were located in minority communities, hired more minority mathematicians thirty years ago, we would not have such a gross under-representation of the minority population in mathematics based fields; the present situation is a direct result of the hiring practices of the mathematics departments over the last thirty years.

2. Data

In 1997, African-Americans, Hispanic/Latinos, and Native-Americans comprised 24.5% of the US population [8], yet they make up only 4.5% of those holding scientific doctorates [11]. It is projected that by the year 2010, the Hispanic population will be the largest minority group. There is little doubt as to the small numbers of minorities participating in the mathematical sciences. As reported in Science [11], of 179 institutions surveyed, 88 universities graduated fewer than one minority Ph.D. in mathematics per year in the time period 1992-1996 and 76 graduated none! The existing data, though depressing, is even worse than it appears. The Science article cited includes a table listing the mathematics departments that have produced the largest number of "minority" doctorates in mathematics, for the years 1992-1996. I was surprised to read the figures for my own department at The University of Arizona, which averaged 2.4 minority doctorates per year for this time period. I obtained a listing of doctoral recipients for the department of mathematics and the program in applied mathematics. There were a total of 62 doctorates awarded during this time period. There were no African-American, Chicanos or Native Americans among this group and only one U.S. born Hispanic of South American ancestry. According to this article, there should have been 12 minority Ph.D.s in this group of doctorates, yet there was only one. There were six Mexican nationals who received their Ph.D.s at this time, which could account for this grossly inflated figure. As it turns out, the data did not ask for citizenship. When reading about data concerning minorities, I cannot

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help but wonder how often citizenship has been ignored.

3. Diversity: What does it mean?
Diversity means that our faculty should reflect the population of this country. Conversations that I have had with faculty and administrators lead me to believe that our professorate is not fully aware of the problems that the minority community faces. Let me provide just three examples.

a) In a conversation that I had with the President of a research university in the Southwest, I pointed out the very small number of Chicano mathematicians at our research universities in the Southwest. The President expressed surprise at this and said that there were lots of mathematicians in Mexico. Why didn't we just go there and recruit?

b) At a large meeting, I was giving a presentation on the small numbers of minority mathematicians at our research universities. After the presentation, a mathematician came up and said that he simply didn't understand the remarks that I made concerning the lack of diversity. He pointed out that they had mathematicians from all over the world. His department was extremely diverse, even though there were no "under-represented minorities" on the faculty.

c) I was talking to the chairman of a mathematics department at a university in the Southwest, and I commented that they did not have a single Chicano faculty member in their department, and had not had one in many years. This university was situated in a city with a high percentage of Mexican-Americans. The department head replied, "Why do we need one?"

Indeed, "Why do we need one?" A fair question, and one that deserves an answer. Who, in a department that is so international in character, cares about the education of the local population? Who is willing to take time away from their research to reach out to a population whose culture, and perhaps language, is so different from that of the university? One natural candidate for these activities is a person who is part of that community, and that is what is lacking. Not only is the local minority culture different from that of the international character of the university, it is often also economically impoverished. This makes it even more difficult to make a connection. I know of many mathematicians who have given of their time to reach out to the local minority community. However, if we were to compare the percentage of university mathematicians who have made such efforts to the percentage of minority mathematicians who have done the same, we would see a tremendous difference in these two numbers. It is natural. We in the minority community care deeply about the minority community, and yet we have been excluded from the very same universities that should be educating us.

It bothers many of us in the Chicano community that foreign-educated mathematicians who grew up speaking Spanish are counted as minorities when they hold academic positions in this country. Some of these individuals empathize with our problems and have contributed to helping these communities, but then so do many other non-Spanish speaking mathematicians. Diversity among the professorate should mean that those who have gone through the K-12 educational system in this country should also be able to participate and succeed at our universities. The chances that a minority faculty member will be interested in working with minority students and be able to positively impact them are higher than for a non-minority. After all, we have gone through the K-12 system, we better understand this culture, and we still have family in this culture, family that is going through those same problems that form barriers to higher education. Notice that I am not saying that minority mathematicians should have these concerns nor do they necessarily have the ability and will to act to try and solve some of these social problems, but many of them do.

4. Lack of respect for U.S. students
There is a joke going around mathematics meetings. We bemoan the fact that many students arriving at our campuses from high school must take remedial mathematics courses. Students entering our graduate courses find it difficult to survive the beginning courses. The joke is that departments will have to develop remedial courses in linear algebra for new faculty.

Of course, all of these comments only apply to U.S. students. Across the country, departments find it difficult to attract good U.S. graduate students. The U.S. students that do show up arrive woefully under-prepared for the rigors of graduate school. Foreign educated undergraduates are much better prepared and fare much better in our graduate schools. Many graduate programs rely very heavily on foreign graduate student enrollment. It would not be a stretch to say that it is U.S. students who are becoming under-represented, both in the graduate schools and among the faculty of these graduate schools.

It is correct to say that foreign students entering our graduate schools are better prepared than the great majority of undergraduates from this country. Is it that foreign students are so much brighter than the Americans? Before jumping to this conclusion, let's think about the

educational systems in this country. We believe in a Liberal Arts education. A student going through our universities must go through a liberal arts curriculum. In many cases no more than a third of the courses that a student takes can come from one department. For many foreign students, the exact opposite is true. A mathematics major in another country means that the student took primarily mathematics courses, probably more than double the number of mathematics courses that a typical U.S. student would take.

We force our students to go through a liberal arts education, and then when they apply to graduate school, we complain that they are not as well prepared as a foreign student. In choosing the foreign student over the U.S. student, graduate programs condemn our own educational system.

We hear all too often the complaints of faculty about the under-preparedness of U.S. students for our graduate programs. Is it really in the best interest of this country to have developed a graduate educational system that almost guarantees that U.S. students will fail? Have our undergraduate programs really failed our own students? When has become. In my own department, 30 of the 62 current faculty are foreign born.

5. Hiring practices of our universities

In 1978, I conducted a survey of Chicano and Native American Ph.D.s [9]. This survey was not restricted to mathematics. One of the questions in the survey dealt with the efforts of these Ph.D.s to gain employment at universities in the Southwest. It will come as no surprise that the vast majority of them tried to find such employment and that most of them failed in this endeavor. There has simply been no interest at these universities in hiring these minority scientists, as evidenced by the data and by the remark that the department head made, "Why do we need them?" How many other Berriozabals have been lost to the minority community because there is no perceived "need" for us? Yet by seeing the impact these individuals have had on their local communities we have dramatic evidence to show why we are needed.

I often talk to new Chicano Ph.D.s, and I am amazed how little interest there is in hiring them at our universities in the Southwest. Time and time again I have seen these

"It would not be a stretch to say that it is U.S. students who are becoming underrepresented, both in the graduate schools and among the faculty of these graduate schools."

I began my graduate studies in 1970, my entering class had more than 20 students in it. I was the only one of the group to receive a Ph.D. In the thirty years since then, have things gotten worse? How could they?

This disrespect for U.S. students came to the fore in an e-mail that was recently sent out. A university had just received a VIGRE (Vertical Integration of Research and Education) grant from NSF. The conditions of this grant specifically state that only U.S. citizens and permanent residents can be supported through VIGRE funds. The mathematician who sent out the announcement for postdoctoral positions included the following statement, "They are unfortunately restricted to U.S. citizens and permanent residents...." The fact that this person would send out this public message makes it appear that he does not feel isolated in his disregard for the education of our citizenry.

The mathematician who sent out this message finds it "unfortunate" that his university has to use federal funds to further the mathematical careers of U.S. citizens. He finds it unfortunate that the net used to attract mathematical talent to his university cannot be more international in its scope. Even a cursory look at the mathematical enterprise of this country will show how international it Ph.D.s ignored as they attempt to find employment. We as a community of scholars have lied to them. We tell them how important it is to pursue those advanced degrees and when they listen to us and achieve these goals, we ignore them. We hire foreign-born mathematicians who have more "potential" and more research credentials.

The e-mail message mentioned above got me to thinking about the Chicano mathematicians that I have known over the years. Unfortunately, that number has not grown much. In 1977, I accepted a position at The University of Arizona. Around that time period, the Chicano mathematicians that I knew at Ph.D. granting institutions in the Southwest were: Efraim Armendariz (University of Texas, Austin); Joaquin Bustos (Arizona State University); Richard Griego (University of New Mexico); David Sanchez (University of California. Los Angeles); Richard Tapia (Rice University); Bill Torres (New Mexico State University). These individuals have all had a positive impact on minority students at their institutions as evidenced by the fact that Berriozabal, Bustos, Tapia and myself are all Presidential Awardees for Mentoring. These individuals serve on many commit-

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tees for the AMS and the MAA. They are called upon to represent the Chicano community on many different committees.

Twenty years later, Bill Torres has left academia, Richard Griego has retired and David Sanchez has moved to Texas A&M. I know of no other Chicano mathematician at any Ph.D. granting institution in the Southwest other than those I have mentioned.* You will observe that our numbers have in fact decreased; yet many mathematicians find it "unfortunate" that they have to restrict their recruitment to U.S. citizens and permanent residents. The situation that I have just described points to a crisis for the mathematical education of the Chicano population. In ten years many of the people that I have mentioned will have retired! Who will represent us in AMS deliberations? It takes at least ten years to move along the faculty ranks to become a Full Professor. This scenario points to the very real possibility that there will be no Chicano Full Professors of mathematics at our Ph.D. granting institutions in the Southwest ten or fifteen years from now! Is it possible that our mathematics departments will look like missionary schools in the future, staffed by apostles from other lands, come to educate the poor minorities?

This is intolerable. Universities must realize that the education of its population is foremost in its mission, and that we, the minority community, should play a prominent role in the education of our children. The federal government has invested large amounts of taxpayer funds to support research in this country. Does the research community believe that publishing papers is the only goal of this support? This support is aimed at universities, not at research institutes. One of the goals of this support is to enable these universities to better educate their citizens. If this is one of the goals, then it has failed us. The number of Chicanos who have earned Ph.D.s in mathematics numbers in the tens. What is needed is not more money to support the research community, but a stronger collective will to educate the children of this country.

6. Elitism in mathematics

There is one fact that is certain. Few U.S. students are choosing mathematics for their undergraduate major. I recently read that fewer than 5% of students who take calculus at our universities choose mathematics for their major. This is a depressingly low figure. Can this be blamed on the K-12 educational system? It would appear that the instruction that they are receiving from a professional department is more to blame for this low number. If mathematics departments and their faculty spent more energy in motivating students to further studies in mathematics, then more and better prepared U.S. students would arrive at our graduate programs.

A question that naturally comes up is why our calculus students do not choose mathematics for their major. An answer could be in the way that we choose to present mathematics. However, I am beginning to think that there is a more basic reason, and that is that mathematicians do not think that mathematics is useful.

I have had the enjoyment of teaching out of the Harvard calculus reform text for several years. It is a real pleasure. The reform movement in calculus has served to make calculus much more germane to science and I applaud the efforts. The reform movement has put new material in the hands of mathematicians. But simply putting this material in their hands is not enough. Mathematicians can continue to teach as they have before, even though the material has a different emphasis. What is needed is a departmental commitment to use the calculus courses to increase the number of students taking mathematics. A different book is not enough to help faculty have a different focus on their teaching.

I am often called upon to talk about minority issues. One of the things that I mention in these talks is that I have managed to increase the number of Chicano students who pursue undergraduate degrees in mathematics. Every time I have mentioned this, a mathematician asks the question, "Why should we encourage minority students to pursue degrees in mathematics when the job market is so bad?" Mathematicians are so focussed on research in mathematics that they do not think much about the uses of an undergraduate degree in mathematics. Mathematical training at the undergraduate level should not have as its only goal the production of new Ph.D.s. An undergraduate degree in mathematics, coupled with a solid knowledge of computer science or some other science, is a very marketable degree. We should encourage more students to pursue this path. However, before we encourage our students in this, I believe that we have to educate ourselves as to the usefulness of undergraduate training in mathematics.

7. Recommendations for change

A large part of our profession deals with the communication of the mathematical enterprise to our students. Yet our professional training does not prepare us well for this activity. Most of the graduate education that a student receives deals with the technical training that is necessary to write a doctoral thesis. This same point of view carries

* In the early 70s I made a formal survey of Chicano scientists in universities in the Southwest, which was the basis for my initial data point on this question. After that point, my knowledge of Chicano mathematicians comes from my position as President of the Society for the Advancement of Chicanos and Native Americans in Science, and my continued interest in this organization.

over once a person joins a research department. There are weekly seminars and colloquia, all directed to the transmittal and creation of new mathematical knowledge.

Mathematics departments should recognize the complex role that faculty have in the mathematical enterprise of this country. The creation of new mathematical knowledge is but one component of the equation. Mathematicians are invited to give colloquia because the faculty is interested in learning about their research results. I suggest that the role of faculty colloquia should be expanded to encompass more than just having talks on research. Individuals, who have developed ideas and programs to serve to increase student interest in mathematics, should be invited to give talks in the regular colloquium series.

There are individuals and departments that have managed to greatly increase the number of mathematics majors. This should be of paramount importance to a mathematics department. Individuals who can speak about their successes in this area should be invited to give talks.

How does one properly mentor a student, and provide a departmental atmosphere that supports students in their pursuit of advanced training in mathematics? We all know that the transition from undergraduate studies to a graduate program is a serious obstacle for students. Having an effective mentoring program in place would greatly help students with this transition.

I believe that mathematics departments should more fully appreciate the central role that mathematics plays in today's job market. The role of calculus instruction should be a central one. Most mathematics departments view this course as a service to the university. Instead we should view it as the student's first real introduction to mathematics. This course should be viewed as a vehicle to increase the number of students who choose mathematics for their major.

As we increase the number of students choosing mathematics for their major, we also have to find ways to support this interest. Research Experiences for Undergraduates is an excellent vehicle for doing this and these activities should be expanded. The private employment sector must also be courted. Internships for undergraduate mathematics majors must be sought out in all of the economic sectors in this country. Mathematics departments have to find ways of integrating the mathematics majors into the life of the department, hiring them to work and maintain the computer system, tutoring and grading, and running help sessions for lower division courses.

Mathematics is fundamental to today's society. We have to recognize our unique and special role in educating the children of this country.

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Graduate Education: Reconsidering Our Response

by Sylvia T. Bozeman, Spelman College and Rhonda J. Hughes, Bryn Mawr College

The EDGE Program (Enhancing Diversity in Graduate Education) is a collaborative effort of Bryn Mawr and Spelman Colleges, designed to increase the number of women and minority students who successfully complete graduate programs in the mathematical sciences. The goal is to strengthen the ability of the women who participate to successfully negotiate the transition from undergraduate to graduate education in mathematics, and ultimately to succeed in graduate school.

The structure of the program involves two basic components: an intensive summer program, and a follow-up mentoring program. Summer activities include two four-week core courses in algebra and analysis; minicourses on selected areas of mathematical research; problem sessions aimed at preparing participants for graduate qualifying exams; and panel discussions by mathematicians at all stages of their careers.

Funding for the EDGE Program is provided by the National Science Foundation, the National Security Agency, and the Andrew W. Mellon Foundation.

Additional information is available from the program's web site: http://www.brynmawr.edu/Acads/Math; click on EDGE.

In the early 90's, women who earned doctoral degrees in mathematics represented one quarter of the total number of degrees earned by U.S. citizens. Among those, women from several minority groups were earning these degrees at an abysmal rate; for example, an average of two or three degrees per year were awarded nationally to African-American women. As professors at small liberal arts colleges, we were motivated by the high interest among our students to find a method that could capitalize on that interest and address the unacceptable national statistics. We envisaged a program that would encourage undergraduate students more broadly to major in mathematics, to go to graduate school, and ultimately to pursue careers in the mathematical sciences. Our first response, an REU-type summer program, was the Spelman-Bryn Mawr Summer Mathematics Program aimed at women at the freshman-sophomore levels. The program, funded for four years by the NSF, ultimately proved to be highly successful in achieving its goal. Of the 32 women who participated, approximately 60% have pursued graduate degrees in the mathematical sciences or related areas. Considering that many of these women were rising sophomores when they participated in the program, we regard that program as highly successful in meeting its goals. Five years later, we reconsidered and altered that response to more pointedly address some of the crucial issues related to the success of minorities and women in pursuing mathematics at the highest levels.

The Second Response

Despite the success of the earlier program jointly sponsored by Bryn Mawr and Spelman Colleges, we continued to experience frustration with the number of talented and ambitious women who still had difficulty negotiating the transition to graduate school. We observed that the high school and undergraduate stages of the "pipeline" received considerable attention from several private and governmental sources, but that attrition still took its toll at the graduate level. Women and minority students were particularly adversely affected by the change in culture in the transition from undergraduate to graduate study. Consequently, at the conclusion of the earlier undergraduate program, we reconsidered our response and decided that a new approach was needed. The result is the EDGE Program—Enhancing Diversity in Graduate Education, a bridge to graduate education in mathematics. This program, funded by the NSF, the NSA, and the Andrew W. Mellon Foundation, consists of an intensive summer program with a follow-up mentoring component.

Perhaps the most important feature retained from the earlier program is an insistence on bringing together a diverse group of students who are challenged not only by the mathematics presented but by the variety of backgrounds, experiences, and cultures represented among the participants. We have realized our goal of diversity in all aspects of the program. The teaching faculty, graduate student mentors, and guest lecturers are a diverse group, united by their support for and belief in the EDGE Program philosophy.

From the beginning, the EDGE Program has presented many challenges to its co-directors, both practical and philosophical. Three of those challenges are discussed here to invite comment and to encourage a continuing dialogue in the concerned community.

How does one identify students who will benefit most from a program of enrichment and mentoring in their efforts to earn doctoral degrees in mathematics?

After only three years of operation and 27 participants, what are the indicators that the EDGE Program has been successful; and how does one measure success?

What value does the EDGE Program experience add to a student's experiences that contributes to her success?

Participant Identification

The identification of program participants presents a complex issue. One can imagine selecting students for such a program to guarantee success by choosing top students from the leading research institutions. Our participants are the top students at their institutions. However, in most (but not all) cases, these students come from small colleges, or smaller universities, where the transition to graduate school will present a more abrupt change in culture. We choose students who have all the prerequisites for success— good grades, participation in summer research programs, demonstrated leadership at their institutions, and exceptional recommendations from their faculty. We choose women who in addition are eager to connect to a community of women mathematicians, and who want the support and mathematical preparation that the EDGE program will provide. With approximately one-half minority women and a variety of educational backgrounds, cultures, and values, each year's participant group represents significant diversity in its composition.

Indications of Success

Of the eighteen students who participated in the first two years, all remain committed to earning a graduate degree in mathematics and no one has interrupted her studies before earning the Master's degree. Three students changed graduate institutions when they felt that their initial choice was not suitable for them. In these three cases, students had the support of the co-directors and often had contact with the other participants through a private electronic bulletin board as they struggled with the decision to change. We feel that the EDGE Program helps women to persist in their graduate studies. The vicarious experiences which they gain from the summer panels of older graduate students and recent Ph.D.'s contribute to their realization that not all graduate programs offer the same experiences, and that one graduate program might better suit them than another one; most importantly, it gives them the courage to change when necessary, rather than to drop out altogether.

The Added Value

The EDGE Program seems to add an element that empowers its participants. It endeavors to give them resources to draw upon in times of difficulty in the form of a support network, mentors at their graduate institutions, a better idea of what to expect, and a more realistic picture of what they will encounter, both in terms of the mathematical and the cultural demands of graduate departments. The program gives them the opportunity to prepare psychologically prior to the beginning of graduate school. The speakers' series provides opportunities to network with mathematicians, many of whom are women, as well as numerous opportunities for informal discussion with the graduate student mentors, themselves at the advanced stages of their graduate work. The participants learn to appreciate the value of study groups and, more generally, the benefits of working with others. Assisted by targeted seminars, students learn to appreciate differences in people and to communicate across lines of diversity in support of their own education. They are encouraged to "de-isolate" themselves, particularly when they are having difficulty. They learn the importance of networking and mentoring and are encouraged to identify their own mentors even as we attempt to assist.

Conclusion

The EDGE Program is a result of re-thinking our response to the challenge of diversity and the associated statistics on mathematicians in the U.S. We encourage and invite other responses in the community. It is clear to us, based in part on the many worthy applicants that we are forced to turn away, that the need is much greater than we alone can address. For the graduate students who do not attend the EDGE Program, we hope to create an awareness of their needs in pursuing graduate education. We call for more supportive measures for those currently under represented in the field of mathematics. There is much more that some graduate programs could do to ensure the success of their students, but we alone cannot effect that change. We hope to move others in the community to join us in addressing the challenge. ■

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Increasing the Number of Minority Ph.D.s in Mathematics

by David Manderscheid, The University of Iowa

Over twenty percent of the approximately one hundred graduate students in the Mathematics Department at The University of Iowa are United States citizens who are minorities[1] from groups underrepresented in mathematics. These numbers are in sharp contrast to the total of twenty-five Mathematics Ph.D.s awarded to underrepresented minorities nationally during the academic year 1998-99, out of a total of 554 Ph.D.s awarded to U.S. citizens.[2] It is also striking that we have such a large minority representation in a relatively sparsely populated state with a low percentage (3.7%) of minority groups. In this article I will explain how we have accomplished this. I will place an emphasis on ideas that work and might be transportable to other institutions.

Prehistory

A 1998 article in *Science* detailed the dramatic underrepresentation of minorities in the earning of Ph.D.s in the sciences.[3] For example, as reported in the article and based on the NSF/NIH/NEH/USED/USDA Survey of Earned Doctorates, during the period 1992-1996, of 179 institutions granting Mathematics Ph.D.s, 76 granted no Ph.D.s to minorities and another 88 averaged fewer than one per year. Moreover, these figures include minorities who are not U.S. citizens. Indeed The University of Iowa was listed as the fourth largest producer[4] of minority mathematics Ph.D.s for the five-year period with nine, but all of our nine were noncitizens, Hispanics from South America and Mexico. These nine students did, however, help to diversify the department and most now hold teaching positions in the United States. We were proud of these facts but we, as a department, felt that we could do more.

The Turning Point

In the early nineties we recruited a number of U.S. minorities but these students, for the most part, struggled in our program. The turning point in our efforts was in 1995 when, on our third try, we were awarded a GAANN (Graduate Assistance in Areas of National Need) grant from the U.S. Department of Education. This grant allowed us to provide full fellowship support for three years to nine U.S. minority graduate students. Of the nine fellowships, two were provided by the University as part of a required institutional match and we committed, assuming adequate academic progress, support as a TA for up to an additional four years for all of the nine students.

The Learning Curve

The students we recruited provided us critical mass and our number of U.S. minority students has climbed since. This has not been, however, without hard work both by faculty and the students. The first problem that we encountered was recruiting students for Fall Semester 1995 after notification during the summer that we received the grant (notification timing has improved considerably with notification for this year's GAANN program being sent out in February). Recruitment of the students was difficult, especially given our lack of a track record with U.S. minority students. But faculty members contacted colleagues at institutions serving a large number of minority students, if not predominately so, and eventually the department was able to fill the slots. This was just the start of the struggle, however, as many of the initial placements of the students proved too optimistic. Moreover the students proved very reluctant to admit they were struggling and instead often chose to isolate themselves. Oftentimes, by the time a problem was identified a solution was much more difficult, if not impossible. Nonetheless, of the nine students who started most have met with success. One received his Ph.D. in 3.5 years and is now an associate professor with tenure at a predominately Hispanic institution in the U.S. We expect that two others will eventually get their Ph.D. Of the remaining students, three have received master's degrees, one of these students is pursuing an MBA and another is in a Ph.D. program in Computer Science.

By the time we were awarded our second GAANN grant in 1998, we had learned a number of lessons which paid off for us. First, our recruiting efforts had yielded three outstanding U.S. minority students even before we got word in April that we had received the grant. Second, the earlier notification allowed us to recruit more effectively for the other five slots we had to fill. Indeed we had no trouble filling them with strong students. Most importantly, however, we put in place mechanisms that have helped all of our minority students to succeed.

What Works

As has been shown at other schools such as the University of Maryland, one person can make a tremendous difference but a departmental commitment is recommended.[5] Our model at Iowa is that of teamwork. At the core of our

commitment is our Minority Student Recruitment and Development Committee. Since January 1998, this committee of seven faculty members has been one of the most active committees in the department, with meetings almost every week and in the summer. Not only do we discuss recruiting and planning, we discuss the progress of the students. Input is provided by me as Director of Graduate Studies but also by three committee members who run *weekly problem sessions* (optional) for the students. These three faculty members also volunteer their time to run an intensive two-week orientation for entering minority graduate students each August, before the start of fall semester. During this orientation the faculty get to know the students both personally and mathematically. These orientations have allowed us to make much more accurate placements of students in first-year courses.

In consultation with the student, each minority student in the department is assigned a *faculty mentor*. The mentor, who can be any faculty member in the department, is a personal contact for the student to talk with about academic and personal issues. Of course the students are welcome to talk with the Director of Graduate Studies and, for that matter, with any faculty member. But the mentor provides another less formal venue and makes the process less intimidating for the student. Moreover, since the mentors check often on the students, it is easier to keep abreast of their progress.

We also have teaching assistants assigned as *peer mentors* for our core first-year courses. These mentors hold problem sessions, have extensive office hours and grade homework. Teaching assistants are picked on the basis of outstanding teaching credentials and their performance in advanced course work. We also assign some of our best TAs to lead seminars during the summer semester, which are designed to help students prepare for Ph.D. comprehensive exams. Both of those innovations have been quite successful. Performance in first-year courses has improved as has the pass rate for comprehensive exams. The peer mentors help create an environment where the goal is for everybody to succeed. They make it easier for students to ask questions, especially minority students.

Further, we expose the minority students to opportunities. For those on GAANN Fellowships, we use GAANN funds to send them to conferences to present research and be exposed to the larger mathematical community. We invite successful minority mathematicians to visit and meet with the students. Finally, we provide social opportunities for the students. These include pizza parties within the department and invitations to parties especially for the students at faculty homes.

Corollaries

I cannot overemphasize that our efforts to help minority students succeed also help all students and the department. The comprehensive exam seminars and the provision of TAs for first-year courses have not only have led to better grades and higher pass rates for all students they have, along with our other efforts, helped create a friendly noncompetitive environment in our graduate program. We have used this environment as a selling point to prospective graduate students. This has led to a higher percentage of students, particularly women and minorities, accepting our offers and a concomitant increase in quality. Our graduate student body is now 32% female and half of our entering class next year will be women while a third will be U.S. minorities. Nothing succeeds like success.

"The peer mentors help create an environment where the goal is for everybody to succeed. They make it easier for students to ask questions, especially minority students."

Outcomes

Of course we are ultimately concerned with the outcome: How have the students, the profession and greater society benefited? Although the focus of many initiatives is to increase the number of minority Ph.D.s in mathematics, this should not be our only focus. In particular, it should not be viewed as a failure, for example, when a student gets a M.S. degree and then leaves the Ph.D. program to pursue a degree in another area or to go to work for industry. This is particularly true for minority students as they often have not had the exposure to career opportunity options that majority students have had. In particular, it

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has been our experience that minority students often choose to go into mathematics because that is what they have been told they are good at and they have not been exposed, necessarily, to how mathematics can be used in other fields. Thus when two of our students who earned M.S. degrees decided they would prefer to continue their studies in Computer Science and Management Science, we were happy for them and pleased that we could help them get to that point.

That said, increasing the number of minority Ph.D.s in mathematics still should be one of our primary goals. For these students often go on to teach others, thus providing important role models both for minority and majority students. Moreover, as we have learned, they are often our best recruiters of new minority students for our graduate program.

Final Comments

Occasionally when we have discussed our successes with others, we have heard comments such as "We used a GAANN for minority students once and it didn't work. They all failed out." or "We tried to recruit minority students but failed and just didn't feel it was worth the effort to try again."

If you have had failures in the past we encourage you to try again. As the numbers over time indicate, significantly increasing the number of minorities in mathematics will not be easy. As our experience indicates, hard work is necessary and there will be a learning curve. On the other hand, the number of minority students in graduate mathematics is so low that just helping one student is an important success.

Another comment we hear is "We don't have any minority faculty members so we don't have a chance." We have five minority faculty members and this certainly has helped our efforts. Nonetheless, the experience of white males, such as myself, that have been involved in our efforts, is that we are often viewed with initial caution but then embraced when it is clear that we are sincere, dedicated and can back up what we are saying. Finally, we often hear "But how do you do it when you are not located in an urban environment?" Our answer is that a more rural relaxed environment can appeal to anyone.

"Although the focus of many initiatives is to increase the number of minority Ph.D.s in mathematics, this should not be our only focus. In particular, it should not be viewed as a failure, for example, when a student gets a M.S. degree and then leaves the Ph.D. program to pursue a degree in another area or to go to work for industry."

We welcome your inquiries for further information about our program and how we might be able to help you with establishing similar programs at your institution.

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[1]For the purpose of this article I will use underrepresented minority in mathematics to mean United States citizens who are African American, Hispanics and American Indians or Alaskan Natives.

[2]Don O. Loftsgaarden, James W. Maxwell and Kinda M. Remick, "1999 Annual Survey of the Mathematical Sciences (First Report)", Notices of the American Mathematical Society, 47(2000) no.2, 231-243.

[3]Jeffrey Mervis, "Wanted: a Better Way to Boost Numbers of Minority Ph.D.s", Science, 281(1998), 1268-1270.

[4]UC Berkeley had 13, University of Arizona 12, SUNY, Stony Brook 10, UCLA and Iowa 9 each.

[5]Duane A. Cooper, "Enlarging the Pool of Black Mathematics Ph.D.s: What we are learning at the University of Maryland", National Association of Mathematicians Newsletter, Summer 1999, 6-7, and Duane A. Cooper, "Lessons at the University of Maryland", MER Newsletter, Fall 1999, vol. 12 no. 1. ■

Attracting Undergraduate Minorities to Mathematics

by Etta Z. Falconer, Spelman College

Minorities are severely underrepresented in mathematics. In the past, this was true at Spelman College, but now five percent of Spelman students are mathematics majors. A comprehensive approach to attracting African American women to the mathematics major and preparing them for graduate study in mathematics has been successful at Spelman College. The Model Institutions for Excellence Program (MIE) supports curricular reform, retention activities, infrastructure development, and student research in science, engineering and mathematics. The Mathematics Department has utilized collaborative programs with science departments as well as programs designed specifically in mathematics to develop strategies for the recruitment, retention and preparation of students for graduate study and careers in mathematics and mathematics-related areas.

In the past 20 years minorities have entered colleges and universities in increasing numbers. In addition, there has been an increase in the number of majors in science, engineering and mathematics (SEM) from minority groups who are underrepresented in these areas. The increase in degrees awarded to minorities has been modest. Therefore, minorities continue to be severely underrepresented in mathematics. Only 2% of African Americans earned a bachelor's degree in mathematics, in contrast with 5% of all U.S. students in 1995. Minorities earned only 2% of the doctorates in mathematics in the same year. Some success has been achieved, but it is far from the magnitude envisioned in the 1970's.

There are some institutions, including Spelman College, that have assumed responsibility for producing minority scientists and mathematicians, and have developed programs for success which incorporate mathematics reform. Spelman has an impressive legacy as a historically Black college for women. Founded in 1881, Spelman College is one of six member institutions of the Atlanta University Center consortium. It is a liberal arts college with a faculty of 150 and a predominantly African American student population of approximately 2,000. The students come from 45 states and 29 countries with only 20% residing in the state of Georgia.

The Mathematics Department has 92 mathematics majors and 12 full-time faculty. Although the curriculum is traditional in nature, newer areas such as dynamical systems and operations research have been integrated into seminars and special topics courses. The department has a Mathematics Laboratory that offers tutorial assistance and computer stations with Internet access. Three mathematics-centered organizations exist for students—the Mathematics Club, the Pi Mu Epsilon Honorary Fraternity, and a student chapter of the Mathematical Association of America.

The Mathematics Department has embraced the mathematics reform movement through improvements in the curriculum, pedagogy, infrastructure, and collaborative activities. Although many of the activities in which the Mathematics Department engages are restricted to the department, Spelman has a long history of cooperation between science and mathematics departments. These interdepartmental cooperative ventures have proven to be very cost-effective and successful in terms of goal attainment. A description is given below of both cooperative and independent projects that help to attract and retain mathematics majors, as well as motivate students to pursue graduate studies in the mathematical sciences.

Model Institutions for Excellence Program (MIE)
Spelman is one of six minority-serving institutions that have been designated as a MIE institution by NASA and NSF. The goal of the MIE Program is to increase the number of underrepresented minorities earning science, engineering and mathematics (SEM) baccalaureates, especially those who will pursue SEM graduate degrees and professional careers. The program supports collaborative activities for all SEM departments as well as activities that are designated for a particular department. There are four components— undergraduate education, undergraduate research, student development and infrastructure development.

In the undergraduate education component, every department revised its beginning *gateway* course in an attempt to increase retention of majors. The Mathematics Department adopted the calculus reform that was sweeping the country. Two faculty leaders, Dr. Jeffrey Ehme and Dr. Yewande Olubummo, experimented with the methodology and led a workshop for the mathematics faculty during the spring '96 semester to enable everyone to discuss and become familiar with the material and pedagogy. We incorporated the presentation of calculus concepts in symbolic, graphical and numerical ways, faculty were given other courses to teach. Students objected at first, particularly those who had calculus in

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high school, but they adjusted after a few months and gave positive evaluations at the end of the course.

The second component of MIE is Undergraduate Research. Faculty provide supervision to 30 MIE Research Interns at the sophomore level, including six mathematics majors. The student receives a $2,500 stipend and the professor is given funds for books and supplies. This early start of providing students with research experiences is proving effective.

Faculty-led Project Focus Teams of two to six students are formed in mathematics, biology, chemistry, physics, computer science and environmental science. MIE Research Interns, participants in other programs, or SEM majors who desire a research experience can join a team. Usually a team consists of students of different classifications which has the advantage of giving training responsibility to upper level students.

These research students join others in giving oral or poster presentations in the Annual Science, Engineering and Mathematics Day in the spring. Funds are also available for students to give presentations at external meetings and conferences such as the MAA Regional Meeting, the NAM Undergraduate Mathfest and NCUR. Some of the presentations were: *Quaternion Geometry and Rotations, The Geometry of Fractals,* and *Complications Involving the Fourth Central Moment.*

A successful component with wide faculty support is the Scholar-Teacher Program. Scholar-Teachers in mathematics, biology and chemistry are recently minted Ph.D.'s who have appointments with teaching, research and student research training responsibilities. A Scholar-Teacher advances her/his research program while learning how to teach with current pedagogical techniques, making her/him very competitive in the workplace. The program also identifies young faculty in current research specialties who can serve as role models and research supervisors for students.

Student Development

The Summer Science and Engineering Program is a bridge program for 40 incoming freshmen that is designed to correct mathematics and science background deficiencies, improve study and test-taking skills, create a bonding between students, and introduce students to Spelman and its Science Program. The Postfreshman Summer Science Program accepts 20 students who are at risk of changing majors due to academic problems, but have been identified by a faculty member as promising if given additional help.

The Freshman Success Program is the primary vehicle for providing assistance for students who are experiencing difficulty in SEM courses. The coordinator administers special tests to identify problem areas, suggests intervention strategies in consultation with faculty, and provides counseling. She also recruits and supervises undergraduate tutors in cooperation with departments. Tutors attend classes, meet with faculty for special instructions, and give tutorials to students.

Center for Scientific Applications of Mathematics

The Center for Scientific Applications of Mathematics (CSAM) promotes faculty research, provides student research training, and fosters the development of interdisciplinary courses. Originally funded by the Kellogg Foundation, the Center now receives its major support from the Kodak Company. Over 60% of the SEM faculty have been associates of the Center. The participating faculty form the core leaders for CSAM activities, including mentoring and supervising students in research, developing and teaching interdisciplinary courses, hosting visiting scientists, and publishing *The Science and Mathematics Journal*. The results have been outstanding. CSAM faculty have many research publications and presentations, and CSAM students and Kodak Scholars have given research presentations at external sites. One of the most important benefits has been the relationships established between mathematics faculty and faculty in other disciplines that are resulting in cooperative research and program endeavors.

Enhancing Diversity in Graduate Education Program (EDGE)

EDGE is a cooperative program between Bryn Mawr College and Spelman College with funding from NSF, NSA and the Mellon Foundation. Its goal is to improve the transition of women from undergraduate to graduate education in mathematics and to improve their success in the graduate program. Each year there are eight to ten participants. The program is directed by Dr. Sylvia Bozeman of Spelman College and Dr. Rhonda Hughes of Bryn Mawr College.

EDGE has two components, an intensive Summer Program and a follow-up Mentoring Program. The Summer Program consists of two four-week core courses in algebra and analysis, two minicourses on selected areas of mathematical research, problem sessions aimed at preparing participants for qualifying exams, and other support activities. The site of the Summer Program alternates between Bryn Mawr College and Spelman College.

The Mentoring Program is based on personalized contact

between the participants who will be in graduate school and the co-directors. In addition, a mentor is identified at the graduate institution to work with the student. An active web site is maintained so participants can easily maintain contact with the directors and with each other. If possible, meetings between the participants and directors take place at professional meetings.

EDGE recruits and selects a diverse group of women. In 1999, there were five minority and five majority students. No two participants came from the same undergraduate institution and no two were planning to attend the same graduate institution. The 2000 Summer Program was held at Bryn Mawr College. [Bozeman and Hughes discuss EDGE in *Graduate Education: Considering Our Response* on page 8 of this volume. Ed.]

Mathematics Enrichment Program

The goal of the Mathematics Enrichment Program is to provide academic enrichment for talented mathematics majors who are interested in a graduate degree or career in the mathematical sciences. Currently there are eight participants— one freshman, one sophomore, five juniors, and one senior. One former participant is now pursuing graduate study in mathematics at Arizona State University. The program is funded by the National Security Agency (NSA). It is directed by Dr. Nagambal Shah and Dr. Jeffrey Ehme.

The program has two components. The Academic Year Enrichment Component which takes place during the regular school year consists of a Weekly Scholars Roundtable and enrollment at the appropriate level in a special topics course in Advanced Linear Algebra, and a full year sequence in each of Real Variables, Abstract Algebra, and Probability and Statistics. Students are also expected to engage in research during their college tenure. The Scholars Roundtable provides a forum for a discussion of topics such as defining derivatives in R^n and infinite dimensional spaces; graphing solutions to differential equations; and stable and unstable solutions of differential equations.

The second component of the NSA Mathematics Enrichment Program is the Summer Mathematics Institute. It consists of daily courses in Probability and Statistics, Topology, Problem Solving, and Computer Applications. In addition students participate in several support activities during the summer.

Faculty Viewpoint

At Spelman a variety of means have been used to implement reform activities into the Mathematics Department. Student learning has become the focal point. In all that has been done, the faculty viewpoint has been valued and respected. One of the most creative faculty members is Colm Mulcahy who was trained as an algebraist, but has developed interests in *Computer Aided Geometric Design, Digital Image Processing, Wavelets, and Digital Signal/Audio Processing.*

Dr. Mulcahy's philosophy is to expose colleagues and students to fun and accessible mathematics just outside the confines of usual undergraduate mathematics. He likes to add interesting examples and projects to the linear algebra and multivariable calculus courses.

Students are able to work on projects that apply mathematics to imaging, data compression and animation. They present their work at national meetings, including topics such as *Breakthroughs in Compression Using Wavelets and Curves* and *Surfaces Behind Computer Animated Films*. Dr. Mulcahy finds funds for these activities through his Boeing grant, CSAM, MIE, WISE (Women in Science and Engineering Scholars Program) and the department.

The recognition of the Spelman Mathematics Department of a need to move outside the confines of traditional thinking has yielded encouraging results. New activities have been explored such as the integration of computer technology in teaching, the integration of research into learning, the exposure of students to interesting real world applications that utilize significant mathematics, and the development of a network of scholars which includes faculty from other disciplines. We are at the beginning, but it is a period of great excitement and promise.

One of our graduates received a Ph.D. in Operations Research this year and three are at dissertation stage. The feeling of accomplishment is captured in the following comments of a student: "As a participant in the Boeing Seminar, *Computer Aided Geometric Design,* I was enlightened to the vast applications of mathematics. My research in CAGD really inspired me to pursue a higher degree in applied mathematics."

At Spelman we see prospective mathematics majors as incredibly bright young women. They succeed because they have the ability to succeed and because we believe that they can. They receive our admiration, support, and belief in their ability as well as our challenge to work hard and do well in mathematics. The success of minority women is not uniquely reserved for Spelman College. It can be the story of any place that seeks it. *Whose responsibility is it to produce minority mathematicians? The answer is: All of us.* ■

The Mathematicians and Education Reform Forum

The **Mathematicians and Education Reform (MER) Forum** seeks the effective participation of mathematicians in mathematics education reform at the K-12, undergraduate, and graduate levels, and the recognition of the importance of these efforts to the well being of the mathematics community. The MER Forum envisages the pursuit of educational reform through informed discussion of educational issues, thoughtful responses to changing educational conditions, and the promotion of exemplary programs. The creation and support of a network of mathematicians with a sustained commitment to mathematics education is central to this vision.

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